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Supply Chain with Operational Research (OR) using Simulation: A Case Study Price of Oil and Production Fluctuation in Kingdom Saudi Arabia (KSA)

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Abstract
Present trends in fluctuations of oil price and production have an impact on supply chain (SC). The study concentrates on the computation on the impact on fluctuation of oil price and production in the kingdom of Saudi Arabia (KSA). The study is attractive and interesting because it uses stochastic simulation as the main and last resort of mathematical operational research (OR) technique and tracking signal. Excel was selected as the main candidate visual object event driven programming (VOEDP) for the computation.
Keywords: Simulation, Stochastic simulation, Tracking signal, operational research (OR), Supply Chain.

1. Introduction

Oil industry has been on the focus of industry during the 20th century, since it is an integral part of the industrial revolution, its price is meticulously observed. Oil historical prices have been through fluctuating cycles as shown below in figure 1.

Fig.1© 2010-2014 Macro Trends website

During the second half of the 20th century, price boomed sharply in two-decade periods: in 1970s and 2000s. This influences world macro-economy as well as micro-sociality. Oil producing countries always watch the downturns apprehensively. The trend at this juncture (Dec2014) brings about this trepidation for those OPEC members. Saudi Arabia is the most influential of OPEC since it is the largest producer of oil with around 12 million barrels daily.

International Energy Agency states that "in the next five years, almost half of global oil demand growth will come from China, and this trend is set to continue to year 2035.Therefore, oil demand from the transportation sector is growing strongly in countries such as China and India. In contrast, oil demand is expected to decline over the next two decades driven mostly by government policies on fuel efficiency and the fact that rates of vehicle ownership are already high". This creates a hesitation in the production decisions for the producing countries. Decisions need to be made based on studies as this study simulates global demand to Saudi decision of production.

In 2004 Penn Well Corporation had done a simulation for the world oil peak production and here is the divergence illustrated between what Penn Well forecasted in figure 2 and what the actual scenario was in figure 3.

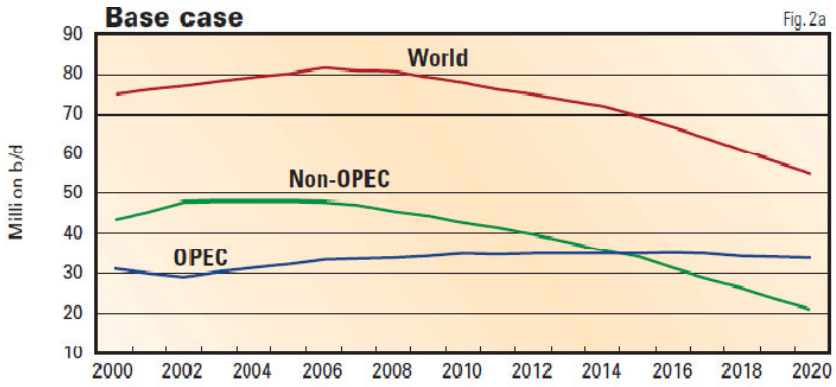

Fig.2Penn Well Corporation © 2004

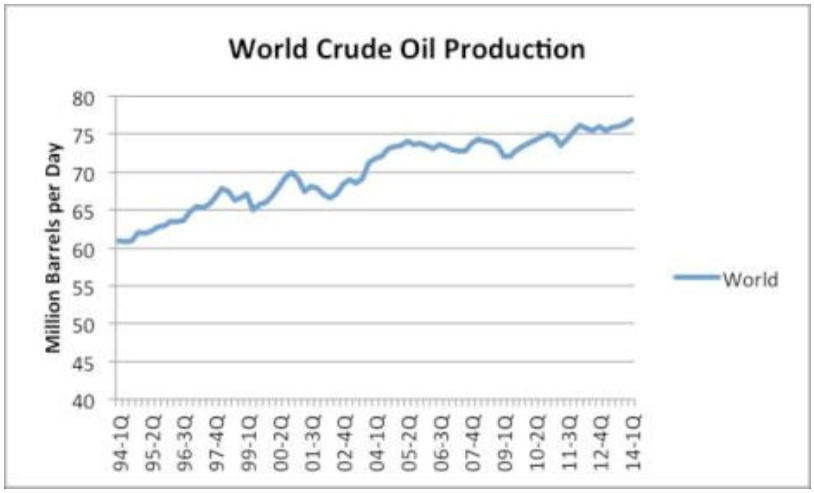

Fig.3 Quarterly crude and condensate oil production, based on EIA data.

Both figures 2 and 3 show a forecast error and it is detailed as deviation and forecast error in table 1. This report sheds light on a simulation of oil production and demand in response to price for the period of 2014 - 2020

Table 1

year	Forecast	Actual	deviation	Forecast error
2005	80,000,000	74,000,000	6000000	
2006	81,000,000	73,500,000	7,500,000	
2007	80,500,000	74,400,000	6,100,000	
2008	80,200,000	74,700,000	5,500,000	5,183,333
2009	78,000,000	73,000,000	5,000,000	
2010	76,000,000	75,000,000	1,000,000	

Simulation is an attempt to duplicate features, appearance and characteristics of a real system, usually via a computerized model (Heizer p 818). Simulation is used in this report for forecasting of the demand and price of crude oil and how it affects Saudi Arabia. Actually Oil is considered a double edged-sword for Saudi Arabia in which it is considered a major income resource of Saudi GDP. “Prosperous for high price, but anxious for lower price” (Albaqshi).

2. Statement of the problem

Prices of the oil in a declining trend (2014) is not known to which extent to be stabilized. This influences Saudi Arabia economy as a major producer and world as consumers. Simulating as an operational research (OR) technique can be utilized as tracking signal tool create for computation on the demand of oil and relate with price can reveal a future overview to stakeholders.

2.1 Purpose of the study

The purpose of the study is to reveal the future demand and price of the oil

2.2 Significance of the study

In literature, the concepts of HMS were associated with a myriad of technical measures. McFarlane (1995) The significant of this study is to examine benefits of developing a simulation of oil prices and production in Saudi Arabia. Also, researchers are trying to see the impact of variables that included in integrated conceptual framework on oil prices and production in Saudi Arabia. The integrated conceptual framework includes two phases with many variables as it will be discussed in the coming section.

2.3 Assumptions

This section is devoted to the assumptions made in this study:

1. It was assumed that the literatures reviewed and utilized in this study were correct
2. It was assumed that the primary sources were correct .
3. It was assumed that the secondary data collected from various sources to base the analysis of the study were correct.

3. Conceptual framework

This conceptual framework was developed by two researchers in early 2014(Al-Salamin Hussain and Tembe Elias)which is designed based on the Homomorphism Conceptual Framework for Effective Supply Chain Strategy as Fig 4 below. As per findings of this study researchers designed an integrated framework which firms, organizations, or governments can take several benefits when implementing the framework properly. It is very important to study the influences of this conceptual framework on price and production in this study as in Tables 2 and Table 3 below.

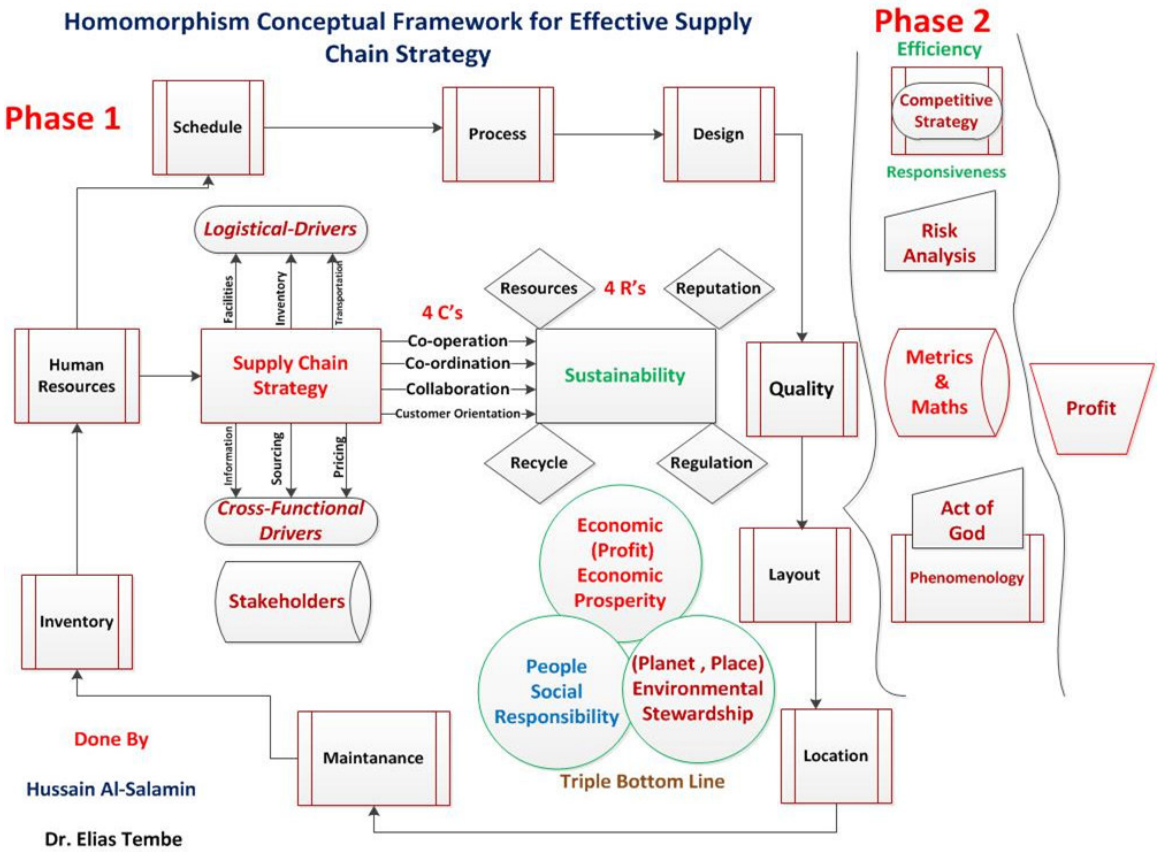

Figure4: Homomorphism Conceptual Framework for Effective Supply Chain Strategy
Source: Hussain Al-Salamin and Elias Ogutu Azariah Tembe(2014), King Faisal University, KSA

3.1 The impact of fluctuation of oil price and production in Phase one which includes:

Table 2

Item	Impact on Price	Impact on Production
10 OM Decisions		
Logistical drivers		
Facility	Centralized vs. decentralized	More locations Vs. Shrinking
Inventory	Pull vs. push system	Safety vs. Cross docking
Transportation	Quick vs. Slow response	Milk runs vs. Direct Shipping
Cross-Functional drivers		
Information	NA	Technology-driven
Sourcing	Lower vs. high response	Reliability for high vs. low volume
Pricing	NA	High demand vs. low supply
Sustainability	NA	NA
Triple bottom line		
Social Responsibility	Increase in price = increase in CSR	Increase in production = increase in SC involvement
Economic Prosperity	Increase in price = increase in economy	Decrease in production = increase in economy
Environmental stewardship	NA	+ production = - environment

3.2 The impact of fluctuation of oil price and production in Phase two

Table 3

Item	Impact on Price	Impact on Production
Act of god (Phenomenology)	Boom in prices	Significant decrease
Metrics and math	NA	NA
Risk analysis	-price = high risk in revenue	NA

When capacity is either overestimated or underestimated, the resulting shortage or surplus can lead to loss of customers and market share. So, the need of simulation is critical. Moreover, utilization which is defined as Heizer and Render as " actual outputs as a percent of design capacity " should be calculated properly. Also, firms need to enhance or improve the ratio of productivity in order to compete. In conclusion, simulation is important but it is not an exact predication and one method to monitor simulation to ensure that they perform well is to use tracking signal which is defined as " a measurement of who well a forecast is predicting actual values" (Heizer and Render).

4. Methodology and Procedures

The collected data were analyzed statistically using two methods. Researchers have applied simulation using Excel program in the first method. The second method is simulation by applying equation manually .

4.1 First Method : Simulation Using Software (Excel Program)

Excel has become one of the most powerful visual programming languages because many multi-purpose properties(attributes) such as Statpro from statistics have been embedded within. The capability and propensity to compute is the most sophisticated stochastic mathematical functionalities such as simulation. Simulation enable researchers to experiment and run thousands of time periods in a matter of minutes or even seconds. This provide managers and decision makers a report with high certainty and low errors.

4.1.1 Oil demand Simulation

Table 4

Cum prob (lower)	Demand for oil	Frequency	Probability	Cumulative Probability
0	84,690,000	2	0.1	0.1
0.1	85,610,100	1	0.09	0.19
0.19	86,724,300	2	0.1	0.29
0.29	86,045,700	2	0.1	0.39
0.39	84,971,700	2	0.11	0.5
0.5	87,856,600	1	0.08	0.58
0.58	88,797,300	1	0.12	0.7
0.7	89,720,800	1	0.05	0.75
0.75	90,375,300	1	0.25	1
	Total	13		
	Average demand	87,561,865		

Year	Random Number	Simulated world Demand
2014	0.631468222	84,690,000
2015	0.497387192	85,610,100
2016	0.853278424	86,724,300
2017	0.677717766	86,045,700
2018	0.335684921	84,971,700
2019	0.910559799	87,856,600
2020	0.418372299	88,797,300
	Average	86,385,100

Results(Frequency Table)			
Oil demanded	Frequency	Percentage	Cum%
84,690,000	1	11.11%	11.11%
85,610,100	1	11.11%	22.22%
86,724,300	1	11.11%	33.33%
86,045,700	1	11.11%	44.44%
84,971,700	1	11.11%	55.56%
87,856,600	1	11.11%	66.67%
88,797,300	1	11.11%	77.78%
89,720,800	1	11.11%	88.89%
90,375,300	1	11.11%	100.00%
Total	9		

4.1.2 Oil price simulation

Table 5

Cum prob (lower)	Price	Frequency	Probability	Cumulative Probability
0	$50.64	1	0.25	0.25
0.25	$61.08	2	0.09	0.34
0.34	$69.08	1	0.11	0.45
0.45	$94.45	1	0.12	0.57
0.57	$61.60	2	0.06	0.63
0.63	$77.45	1	0.1	0.73
0.73	$107.46	3	0.02	0.75
0.75	$109.45	3	0.11	0.86
0.86	$105.87	3	0.14	1
	Total	17		
	Average demand	77.55		

Year	Random Number	Simulated Price
2014	0.014280722	50.64
2015	0.481092856	61.08
2016	0.152906821	69.08
2017	0.445875556	94.45
2018	0.897062705	61.6
2019	0.332624838	77.45
2020	0.809187338	107.46
	Average	74.54

Results(Frequency Table)			
Oil Prices	Frequency	Percentage	Cum%
$50.64	1	11.11%	11.11%
$61.08	1	11.11%	22.22%
$69.08	1	11.11%	33.33%
$94.45	1	11.11%	44.44%
$61.60	1	11.11%	55.56%
$77.45	1	11.11%	66.67%
$107.46	1	11.11%	77.78%
$109.45	1	11.11%	88.89%
$105.87	1	11.11%	100.00%
Total	9		

4.2 Second Method : Simulation using equation manually

4.2.1 Oil demand Simulation

Table 6

Oil consumption		Oil demand	probability	Cumulative probability	Random-Number intervals
2005	1	84,690.000	.10	.10	01 through 10
2006	2	85,610.100	.09	.19	11 through 19
2007	3	86,724.300	.10	.29	20 through 29
2008	4	86,045.700	.10	.39	30 through 39
2009	5	84,971.700	.11	.50	40 through 50
2010	6	87,856.600	.08	.58	51 through 58
2011	7	88,797.300	.12	.70	59 through 70
2012	8	89,720.800	.05	.75	71 through 75
2013	9	90,375,300	.25	1.00	76 through 00
Total			1.00		

year	Random number	Simulated demand
2014	10	84,690.000
2015	24	86,724.300
2016	03	84,690.000
2017	32	86,045.700
2018	23	86,724.300
2019	59	88,797.300
2020	95	90,375,300

4.2.2 Oil price simulation

Table 7

Oil consumption		Oil price	probability	Cumulative probability	Random-Number intervals
2005	1	$50.64	.25	.25	01 through 25
2006	2	$61.08	.09	.34	26 through 34
2007	3	$69.08	.11	.45	35 through 45
2008	4	$94.45	.12	.57	46 through 57
2009	5	$61.60	.06	.63	58 through 63
2010	6	$77.45	.10	.73	64 through 73
2011	7	$107.46	.02	.75	74 through 75
2012	8	$109.45	.11	.86	76 through 86
2013	9	$105.87	.14	1.00	87 through 00
Total			1.00		

year	Random number	Simulated price
2014	10	$50.64
2015	24	$50.64
2016	03	$50.64
2017	32	$61.08
2018	23	$50.64
2019	59	$61.60
2020	95	$105.87

Table 8 U.S Energy Information administration & OPEC website 2014-11-15

year	KSA production	OPEC Basket price	World consumption	Year	Simulated world demand	Simulated price
2005	11,096,000	$50.64	84,690.000	2014	84,690.000	$50.64
2006	10,665,400	$61.08	85,610.100	2015	86,724.300	$50.64
2007	10,248,600	$69.08	86,724.300	2016	84,690.000	$50.64
2008	10,782,300	$94.45	86,045.700	2017	86,045.700	$61.08
2009	9,819,200	$61.60	84,971.700	2018	86,724.300	$50.64
2010	10,642,300	$77.45	87,856.600	2019	88,797.300	$61.60
2011	11,264,300	$107.46	88,797.300	2020	90,375,300	$105.87
2012	11,725,700	$109.45	89,720.800			
2013	11,600,400	$105.87	90,375,300			

e work information based on customer specifications for OH (i.e. the resource holon) to prepare the workforce that will handle the machines. At the threshold of workforce sizing, both the MH and OH, which compose the input holon, will generate their respective data items via Equations (1) to (3), for the use of FH (i.e. the intermediate product holon) to conduct the exponential smoothing. The forecast outcomes of Equation (4) of FH will be channelled into ZH (i.e. the final product holon), which completes the procedure using Equation (5) — adjust the workforce size of OH. Essentially, the FH and ZH belong to the output holon. Some negotiation might take place around the beginning and the end of the process flow, between the MH and the customer side (i.e. the external environment) as well as between the ZH and the human resources division (i.e. the internal environment). As the whole process will repeat for every production period, a database has to be integrated into each of the holons for efficient information storage and retrieval.

5. Discussion

To achieve the objective of this study, researchers used dual methods of simulation. The first method is simulation using software while the second is simulation using equation manually. Illustrated in table sets. 4,5, 6,7 & 8, there is a relatively declining trend of world oil demand while price is in sharp decrease ranging from $ 50 to $ 61 until 2019. This will make Saudi Arabia get safety inventory that carries high holding cost. Moreover, the price of $ 60 is the target price of Saudi Ministry of oil and any deficit of this price will result in GDP shortage.

Saudi is facing more than one obstacle based on the simulation results in this report. First, oil price sharply declines that will lead to GDP shortage. Consequently, this can have adverse effect the government spending for the next decade at least in various aspects such as infrastructure, housing loan lending, agricultural growth, industrial growth, financial investment and future plans.

Second, the high production that has been sold in a satisfactory price can have a part of costly safety inventory in which the world demand is in decrease for the next five (5)years. This can affect the revenue and lower the total profitability as a result of high volume inventory and several refinery pending. Consequently, it will affect the supply chain, labor lay-off and many other aspects. Unemployment rate will be affected considerably as a result of this dramatic decline and ultimately will reflect on the Saudi social standards. As Saudi Arabian Ministry of Labor has plans and programs aiming atreducing unemployment rate, these changes can significantly disrupt their target and effort.

Third, the world decrease in oil demand has several related issues, such as using alternative power, using the reserves, global shrinking economy and level of product availability. In table.7 there is an obvious rising demand of oil until 2013 as a peak point, but there is a gradual decline simulated world demand until 2019 with lower demand than 2013. In 2013, the world demand was 90,375,300 while the simulated world demand ranges from 84,000,000 to 86,000,000 in five (5) successive years until 2019.

6. Conclusion and Recommendation and further study

After implementing this study, researchers found that this study covers the results of simulated world oil price and production and its impact on Saudi Arabia economy. This may direct the government and firms to get benefits from these results and implement different strategies to strengthen Saudi economic trends towards global challenges. The aim of this study was to show the impact of world oil price and production on Saudi strategic effectiveness in the oil industry. The findings show that the world oil demand in future will direct Saudi Arabia to adapt its strategic plans regarding oil production in which there is a declining demand for oil and Saudi needs to act accordingly.

The researchers highlight three prominent recommendations based on the study findings:

1. Saudi Arabia needs to exploit and attain a variety of income resources to encounter effectively any

sudden change of prices and demand issues.
2. Saudi Arabia needs to rebalance its production in which price will be in a reasonable equilibrium. Therefore there will not be a burdening inventory.
3. Saudi Arabia needs to consider the pull system production in which balance depends primarily on the world demand.

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